

Influence of floor type during fattening on pig cleanliness and microbiological contamination of pigs and carcasses

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Abstract

The aim of the study was to assess the impact of cleanliness on microbiological contamination of pigs and corresponding pork carcasses.

Pig cleanliness was assessed at farm and slaughterhouse using a five-point scale on 4 anatomical areas: rear, back and both flanks. Microbiological sampling was conducted by swabbing 100 cm² on 4 sites (ham, loin, brisket, shoulder), on pigs and corresponding carcasses. On each sample, aerobic mesophilic bacteria (AMC) and enterobacteriaceae (ENC) were enumerated, and presence of Salmonella detected.

At the farm pigs are dirtier, with 40% of their surfaces scored as 0 or 1, but pigs can be considered clean. Pig cleanliness varies according to the floor type used during fattening. Bacterial contamination of pigs varies according to the cleanliness score: differences between dirty and clean pigs in AMC and ENC, are respectively 0.8 and 1.4 log₁₀/400 cm². Whereas cleanliness varies according to floor type, and contamination is linked to cleanliness, the relationship between floor type and pig contamination is not proportional.

At slaughterhouse, due to the water spraying during lairage, pigs are very clean: 94% of their anatomical areas are scored as less or equal to 1, the rear of the pigs being dirtier than the back or the flanks. Bacterial contamination is reduced by the process: AMC and ENC are respectively 0.7 and 1.7 log₁₀ lower on average on pork carcasses than the live pigs. No link between the bacterial contamination of carcasses and visual cleanliness of the pigs or their initial contamination could be established.

The overall prevalence *Listeria monocytogenes* and *Salmonella* on the skin of pigs at the farm is very low (respectively 8% and 1%). Due to process, the prevalence of salmonella decreases during slaughter from 13% at bleeding to 7% before chilling; prevalence could not be linked to pig cleanliness nor contamination.

Introduction

It is classically accepted that the slaughter of cattle or sheep with excessively dirty hides will result in increased bacterial contamination at certain sites on the carcass. Thus, since 2006, European food business operators are to take adequate measures about the cleanliness of animals going to slaughter or accepted onto the slaughter premises, according to Regulations (EC) No 852/2004 and 853/2004.

In pig production, several studies have been carried out to characterise the effect of floor type during fattening on environment, welfare and pig cleanliness (Courboulay et al, 2003). However, little information is available on the impact of cleanliness on microbiological contamination of pigs and corresponding pork carcasses.

Thus, microbiological contamination in relation to cleanliness and floor type has to be evaluated in order to give appropriate information for the meat processing industry.

Material and Methods

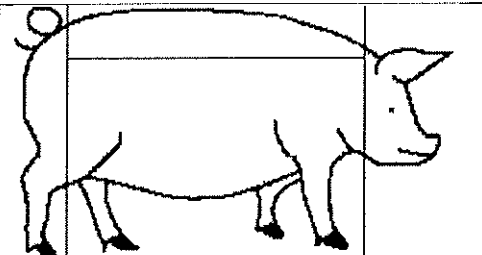
Pig cleanliness was assessed using a five-point scale on 4 anatomical areas: rear, back and both flanks (Fig. 1). On a first trial at slaughterhouse level, cleanliness was scored on 10 randomly chosen pigs at bleeding point, from 10 batches and 6 repetitions, in one abattoir. On the second trial 20 pigs cleanliness was assessed at the farm, before loading, on 17 batches from 37 farms; 4 floor types being represented: slatted floor (SF), partly slatted floor (PSF), litter (L), outdoor (O). The pigs were then slaughtered the following day, after conventional transport and lairage, in three different abattoirs.

Microbiological sampling was conducted by swabbing 100 cm² on 4 sites (ham, loin, brisket, shoulder), on pigs at farm on the lairage pens or at the bleeding point of the slaughter; their corresponding carcasses were also swabbed at the end of the slaughter line.

On each sample, aerobic mesophilic bacteria (AMC) and enterobacteriaceae (ENC) were enumerated. Presence of *Salmonella* was tested on samples from each stage, whereas *Listeria monocytogenes* was only monitored at farm level.

Statistical analyses were performed using SAS procedures: Khi-2 and CATMOD for cleanliness; CORR, GLM and Tukey multiple comparisons of means for bacterial contamination. Nested effects were used on the second trial analysis due to unbalanced data (all floor types not represented in all abattoirs).

Figure 1: Visual appreciation of pig cleanliness

Score	Visual scoring of cleanliness	
0	No visual contamination	
1	<25% of the surface considered dirty	
2	25 to 50% of the surface considered dirty	
3	50 to 75% of the surface considered dirty	
4	>75% of the surface considered dirty	

Results

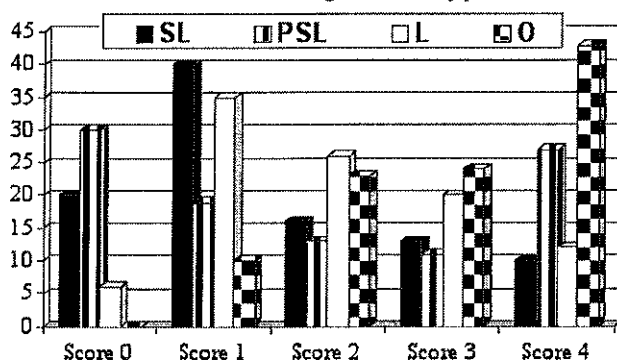
Pig cleanliness

At slaughterhouse, pigs are very clean at the bleeding stage: 94% of their anatomical areas are scored as 0 or 1. We observed higher variations between batches and repetitions than between animal from the same batch. Regarding the different anatomical areas scored, the rear of the pigs is dirtier than the back or the flanks. These good results are mainly due to the water spraying during lairage, which improves cleanliness as previously reported by Vandenberghe et Chevillon (2001).

On the farm lairage pens, pigs are dirtier, with respectively 40% of their surfaces assessed as less or equal to 1 and more or equal to 3; but pigs can be considered rather clean. These results are close to those observed by MAW et al (2001), who scored 33% of the pigs clean or very clean, and 43% dirty or very dirty.

As expected, pig cleanliness varies according to the floor type used during fattening (Fig. 2): O pigs are the dirtiest, SL pigs the cleanest, PSL and L pigs having in-between situations. Courboulay et al (2003) found as well that pigs are cleaner on SL than PSL. For each floor type, farm conception and housing practices are likely to influence pig cleanliness. Floor type of lairage pens and water spraying during lairage before transport, as well as meteorological conditions, may also contribute to the observed differences between farms.

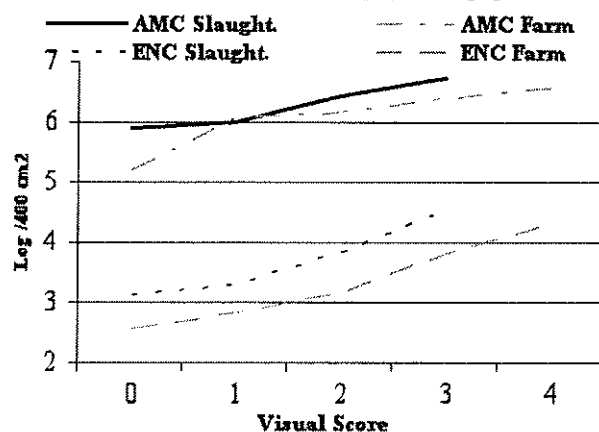
Figure 2: Visual scores according to floor type



Microbiological contamination

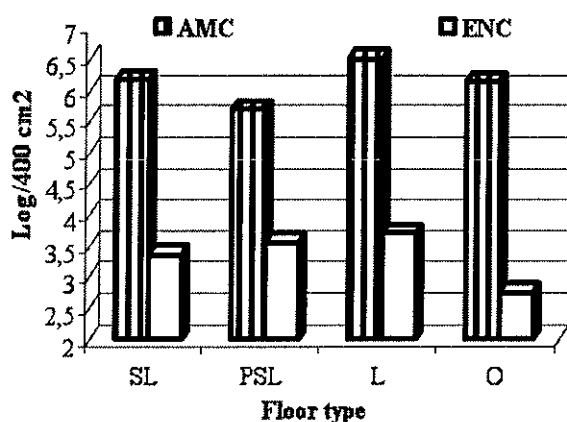
Pig contamination is equivalent at farm and slaughter levels, with on average about $6 \log_{10}/400 \text{ cm}^2$ for AMC and $6 \log_{10}/400 \text{ cm}^2$ for ENC. Microbiological contamination of pigs varies statistically according to their cleanliness score at the farm and at the slaughterhouse (Fig. 3), but at slaughter the batch is the main factor of variation. The differences between dirty (score ≥ 3) and clean (score 0) pigs in AMC and ENC, are respectively 0.8 and $1.4 \log_{10}/400 \text{ cm}^2$ at slaughter, and 1.4 and $1.7 \log_{10}/400 \text{ cm}^2$ at farm.

Figure 3: Contamination of live pigs and pig cleanliness



Whereas cleanliness varies according to floor type and contamination is linked to cleanliness, the relationship between floor type and pig contamination is not proportional (Fig. 4). For instance, O pigs have the lowest ENC contamination despite their highest visual score; L pigs have the highest microbiological contamination despite their in-between score.

Figure 4: Contamination of live pigs and floor type



Average bacterial contamination of pork carcasses at the end of slaughter line is respectively about 5 $\log_{10}/400\text{cm}^2$ and 1,5 $\log_{10}/400\text{cm}^2$ for AMC and ENC, which is closed to values previously reported in France by non destructive methods (Minvielle et al, 2002). No statistical link between bacterial contamination of carcasses and visual cleanliness of the pigs or their contamination could be established, the strongest factors of variation being the batch on the first trial and the abattoir on the second trial. Gill (2003) previously reported that the relationship between the cleanliness of animals and the microbiological condition of carcasses is controversial. Carcass contamination is, respectively for AMC an ENC, about 0.7 and 1.7 \log_{10} lower on average than the live pigs, due to the reported influence of slaughter process (Pearce et al, 2004).

The overall prevalence *Listeria monocytogenes* on the skin of pigs at the farm, 8%, is low but close to the 7% reported by Salvat et al.(1997). On a batch analysis, 37% of the farms have at least one pig positive, with strong variation among batches (from 0 to 95% of the controlled animals are positive). No link between *Listeria monocytogenes* presence and pig cleanliness or floor type could be established.

At farm level on the lairage pens, the individual pig prevalence of *Salmonella* is only 1%, with 20% of the batch having at least one positive pig; the individual prevalence of the corresponding carcasses is 5% at the end the slaughter line. These results are lower than the 38% of positive batches reported by Beloeil et al (2004) with environmental sampling at the end of the finishing period.

As previously reported (Berends et al, 1997 ; Bouvet et al, 2003), *Samonella* prevalence decreases during slaughter process, from 13% at bleeding to 7% at the end of the linc in the first trial.

The prevalence observed on the carcasses at the end of the slaughter line is lower than those generally reported in France (about 12% according to professional annually compiled data and 18% from the 2006-2007 EU baseline survey on the prevalence of Salmonella in slaughter pigs).

Individual Salmonella presence at the end of the process line is not statistically linked to salmonella presence (at farm or bleeding point) neither to pig cleanliness nor contamination. These results differ from those recently reported by Rossel et al (2009), who found, on a Bayesian networks analysis of batch, that carcass contamination is directly linked to the skin contamination of live pigs before stunning, and that skin contamination is connected with the contamination of lairage.

Discussion and Conclusion

In our study, we confirmed that cleanliness and contamination of pigs are clearly linked, and that floor type during fattening influences pig cleanliness and thus their bacterial contamination.

Nevertheless, in a classical slaughter process with conventional pigs, pig cleanliness and initial contamination don't appear to be of particular concern for microbiological contamination of pork carcasses at the end of the slaughter line. Other major factors of variation, as batch (farm conception and housing practices; floor type and water spraying...) and slaughter (abattoir conception and equipment ; application of good hygiene practice and respect of procedures based on the HACCP principles), may have masked or levelled the effect of pig cleanliness or initial contamination. With extreme conditions, ie very dirty pigs and bad hygiene procedures during slaughter, results may be also different. Further risk factor data analysis need to be conducted to assess the impact of pig initial contamination on Salmonella contamination of pigs and carcasses.

Despite our reassuring results, pig cleanliness should not be neglected: it is used to appreciate welfare and influences working conditions, and it is an obligation in EU regulations on food safety.

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Chlorate concentration in the jejunum and cecum in growing pigs when supplemented in feed.

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Prior research has demonstrated that oral administration of chlorate and nitrate results in reduced risk and / or concentration of *Salmonella enterica* fecal shedding of infected pigs, poultry and ruminants. The effect of chlorate is concentration dependent *in vitro*, but the concentration of chlorate in the GI tract has not been measured *in vivo*, and consequently the optimal dose of chlorate is poorly defined. We administered three dosages of chlorate (0, 40 and 120 mg/kg/day) and nitrate (0, 2 and 8 mg/kg/day) to 18 growing pigs using a 3 x 3 factorial study design. After 1 or 5 days of treatment subjects were humanely sacrificed to allow collection of jejunal and cecal content samples. The dose of chlorate and nitrate was at or doses associated with suppressed *Salmonella* shedding in a prior study in our lab. Samples were assayed using LC-MS-MS and chromatographic methods.

Chlorate concentration was higher in jejunal content from pigs given 120 mg / kg /day dose of chlorate (54 ppm) than those given 40 mg / kg / day (17 ppm) or controls (<0.1 ppm). The 120 mg / kg / day dose of chlorate was associated with higher chlorate concentrations in the lower intestinal tract, although concentrations detected were much lower than for jejunal samples (cecal, 3.7, colonic, 0.3 ppm). Chlorate concentration was not dependent on duration of treatment or nitrate dose. Nitrate concentration varied from 1-11 ppm, but was not reliably predicted by any factors studied. The low concentration of chlorate found in the lower GI tract (cecum and colon) contrasts with much higher concentration required for *Salmonella* suppression *in vitro*. It is possible that lower chlorate concentration is effective *in vivo*, or that higher doses may be necessary to achieve optimum *Salmonella* suppression effect *in vivo*.